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Original Article

Impact of Different Weed Interference Durations on the Yield and Oil Content of Black Cumin (*Nigella sativa* L.).

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ABSTRACT

In the context of organic farming where the use of herbicides is restricted, blackseed is highly vulnerable to weed pressure because of its sensitivity to its effect. We therefore designed the project to determine when blackseed should receive protection from weeds. For this purpose, an experimental trial was conducted using a Randomized Complete Block design with seven treatments and three replicates using an experimental area located at the Grdarasha Research Field, Salahaddin University, Erbil, Iraq. In addition to weed-free plots and untreated weed infested plots; there were also weed-free plots maintained for 15, 30, 45, 60 & 75 Days After Emergence. According to the findings from this study, long time weed interference significantly reduced growth, seed yield and oil content. Plots known to have been kept free of weeds were found to yield the highest seed yield (1128.4 kg ha^{-1}) and lowest yield loss (9.7%) were achieved in the weed-free plots and in durations where weeding was maintained for at least 30 days after emergence. In full-season weed-free, the large amount of oil content and oil yield were 38.75 and 437.25kg ha-^{1}. This is primarily attributed to it producing a greater seed yield because of no early weed competition and the lowest in the weedy check plot (27.92 and 63.534kg ha^{-1}). At the same time the highest total dry weight (176.65 g m^2) and the highest number of weeds (286.67 weeds m²) occurred in the weedy check plots. The period around 45 DAE was identified as the most critical period for weed control; delaying weed control beyond this period resulted in the greatest reductions (>10%) in yields and total oil yields. The findings of this study show the major importance of timely control of weeds for increasing *Nigella sativa* L. production and decreasing competition associated with weed control.

Keywords: Blackseed, weed interference, critical period for weed control (CPWC), seed yield, oil content.

1 Introduction

The annual herbaceous plant Black seed (*Nigella sativa* L.), commonly referred to as Black cumin, is a member of the Ranunculaceae family and has numerous traditional medicinal applications. Due to its high edible oil content (30–40%), black cumin also has substantial commercial potential as a spice [1,2]. Thymoquinone, a strong antioxidant that has been demonstrated to offer protection against specific diseases, is the primary active ingredient that was extracted from the essential oil of black cumin [3].

Plants experience both biotic and abiotic stressors throughout their life cycles. The most significant biotic element influencing the production of medicinal plants is weed management, particularly in organic farming systems where the use of synthetic herbicides is forbidden [4]. Black cumin (*Nigella sativa* L.), for instance, has slower early growth rates than weeds, especially under seed production procedures. Medicinal plants are typically less competitive than weeds and are highly crowded by annual weeds when sown. Weeds competing with black seed can lead to a decrease in crop yield ranging from 60% to 85% [5].

A diverse range of important medicinal herbs exists in the Kurdistan region, which contain potent bioactive secondary compounds and have been examined for their therapeutic properties by many researchers worldwide [6]. The secondary metabolites in medicinal plants have been demonstrated to be influenced by the density of weeds and plants [7].

Finding the ideal time to perform weed control operations is the first step in creating a comprehensive weed management program. The best time to put weed management measures into place is indicated by the key weed interference period [8].

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Therefore, determining the key period for weed control is essential. An Integrated Weed Management program's diagrammatic component is the Critical Period of Weed Control. Weeds must be managed throughout this stage of the crop growth cycle to avoid output losses [9].

Understanding the Critical Period of Weed Control (CPWC) is essential for determining the necessity and timing of weed management, as well as for optimizing herbicide application economically and biologically.). The purpose of this study is to determine the crucial weed control time for black cumin and to assess the effects of different weed competition periods on the crop's growth and yield.

2 Material and Methods

2.1 Experimental location

The experiment was carried out in Hawler province at Grdarasha Research Field/ College of Agricultural Engineering Sciences / University of Salahaddin -Erbil with GPS coordination of (Latitude 36°4' N and Longitude 44°2' E) and with altitude 415 meters above sea level, during the winter growing season of (2024 – 2025).

The 0–30 cm soil layer was characterized by slightly alkaline pH (7.6) and low salinity (EC 0.2 dS m^{-1}) while, the organic matter (O.M) content was 1.2%. Based on particle size distribution (46.1% sand, 21.2% silt, and 32.7% clay), the soil was classified as sandy clay [10]. The experimental plots were established through two vertical plowings, followed by land leveling and soil softening, and latterly reused with a rotavator. Eventually, the seeds were manually sown on November 10, 2024, at a sowing rate of 15 kg per hectare for black seed under rainfed cultivation cumulative rainfall in Erbil reached 212.8 mm during this period.

A factorial experiment using a Randomized Complete Block Design (R.C.B.D.) with three replications and seven plots was carried out under a naturally existing weed population. Each plot had five rows spaced 30 cm apart and was 1.5 m by 1.5 m. For ensuring ease movement during experimentation, the blocks were placed vertically with a one-cadence buffer zone in between. The crop was kept weed-free at 0, 15, 30, 45, 60, and 75 days after blackseed emergence by hand pulling weeds using a single factor of treatment.

1. Weedy check Weedy check: Weeds are allowed to grow and compete with the crop throughout the entire crop life cycle.

2. Weed-free: Weeds are removed from the time of emergence until harvesting, ensuring no competition between weeds and the crop.

3. Duration 1 (15 DAE): Manual weeding began 15 days after crop emergence and continued until harvest.

4.Duration 2 (30 DAE): Manual weeding began 30 days after crop emergence and continued until harvest.

5. Duration 3 (45 DAE): Manual weeding began 45 days after crop emergence and continued until harvest.

6. Duration 4 (60 DAE): Manual weeding began 60 days after crop emergence and continued until harvest.

7.Duration 5 (75 DAE): Manual weeding began 75 days after crop emergence and continued until harvest.

2.2 Data collection

As seen in Table (1), a variety of annual, biennial, and perennial weeds with broad and narrow leaves emerge throughout the fiel d.

Table 1: Types of Weeds Spread in the Experimental Field.

Narrow leaf weeds			
Common name	**Scientific name**	**Family**	**Grown season**
wild oats	*Avena fatua* L.	Poaceae	Annual winter
Wild barley	*Hordium glauca* L.	Poaceae	Annual winter
Canary grass	*Phalaris minor* L.	Poaceae	Annual winter
Broad leaf weeds			
Common name	**Scientific name**	**Family**	**Grown season**
shepherd's-purse	*Capsella bursa-pastoris*	Brassicaceae	Annual winter
split-leaf lettuce	*Lactuca seriola*	Asteraceae	Annual winter
drug fumitory	*Fumaria officinalis*	Papaveraceae	Annual winter
Black mustard	*Brassica nigra* L.	Brassicaeae	Annual winter
White top	*Cardaria draba* L.	Brassicaeae	Perennial
Marshmallow	*Malva parviflora*	Malavaceae	Annual winter

Wild carrot	*Doucus carota*	Apiaceae	Biennial
Cleavers	*Galium aparine*	Rubiaceae	Annual winter
Spurge	*Euphorbia heliscopia*	Euphorbiaceae	Annual winter
Milk thistle	*Slibyum marianum*	Asteraceae	Annual winter
Indian sweet clover	*Melilotus indica*	Fabaceae	Annual winter

Weed infestations estimated at the end of each treatment by using two 0.5 m × 0.5 m quadrats plot also average calculated. For recording weed density (no.m^{-2}) and dry weight (g) of all weeds will harvest m^2 also allow them to dry for 2- 3 days at room temperature (25°C) and also dry in an oven at 70°C till the constant weight achieved.

Ten plant samples were selected from the center of each plot; the border row were neglected. Next, the following properties of the plant sword samples were measured:

Plant height (cm), number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsules^{-1}, weight of 1000 seeds (g), seed yield (kg ha^{-1}), yield loss (%), biological yield (kg ha^{-1}), harvest index (H)(%) , oil content (%) and oil yield (kg ha^{-1}).

2.3 Statistical analysis

Duncan's new multiple range test at 5% level and analysis of variance in a randomized complete block design were used by SAS (2001) to compare quantitative trait means.

3 Results and Discussion

3.1 Total Weed Density (no. m²:

As seen in Figure 1, the length of weed competition significantly affected the overall weed density. In contrast to Weedy plots, which had the highest number of weeds (286.67 plants per square meter), Weed-Free plots had the fewest weeds (0.0 plants per square meter) because of the constant and continuous elimination of weeds during the growth season. A decrease in weed density happens when the window of opportunity for weed competition is reduced. According to a newly emerging pattern of plant growth, the reduction in weed density is a result of either fewer competitive days or a restricted number of days for weed germination and establishment. However, if the weeds are allowed to compete for a longer period of time, they will produce multiple germination flushes, which will result in higher weed establishment densities. Previous studies by [11] on linseed and [12] on black seed also found that weed infestations were highest in Weedy Check plots and lowest in Weed-Free plots. The study's findings emphasize the idea that timely, consistent weed control methods are an effective way to reduce weed complexes and enhance crop performance.

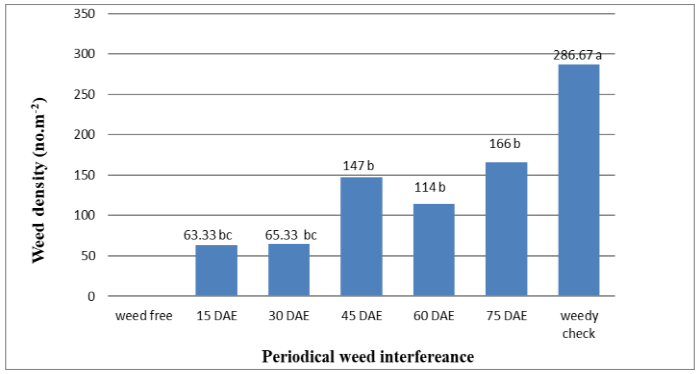

Figure 1: Periodic weed interference's impact on the weed's density.DAE (day after emergence).

3.2 Total weeds dry weight (g m^2)

The dry weight of weeds exhibited an upward trend with extended competition periods, and this rise in weed dry weight at each increased competition period was statistically significant (fig 2).The weedy check plot produced larger total dry weights (176.65 g m^{-2}) demonstrating that prolonged weed growth leads to greater biomass accumulation, no dry weight of weed was observed in plots that were maintained weed-free through consistent hand hoeing during the growing period. The total weed dry weight was reduced by increased lengths of time of weed-free periods as reflected in the overall dry weight measured at duration 1 (15 DAE), which was (7.73 g), as opposed to duration 5 (90 DAE) which was (95.96 g), confirming the effects of increased competition time on total biomass accumulation show in (fig 2). In the case of weeds, the dry weight was related to weed density. Regarding weed dry weight in fenugreek and black cumin crops, the results are in line with those of [12,13].

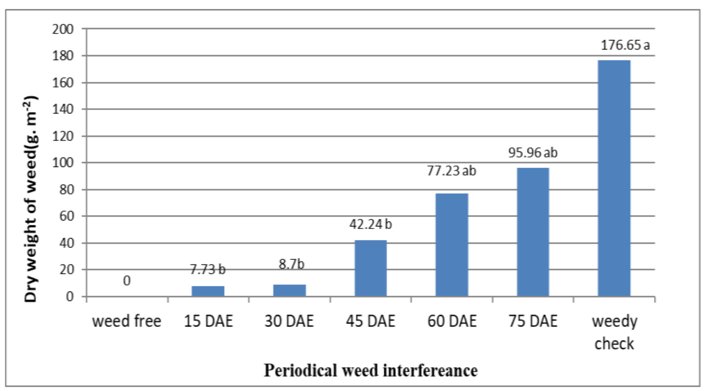

Figure 2: Periodic weed interference's impact on total dry weight of weeds. DAE (day after emergence).

3.3 Plant Height (cm)

The height of black seed plants was significantly impacted by weed competition. The black seed plant was shown to grow considerably taller when competition was lessened. Table 2 illustrates the statistically significant variations in black seed plant height between the various weed treatments. According to [14] the height of black seed plants in each treatment was influenced by genetic type, weed density, and weed type. The weedy check group had the lowest height (42.30 cm), while the no weed competition treatment group had the highest height (58.66 cm). The higher level of competition and the inhibitory effects of weeds, which prevent crops from accessing vital nutrients and moisture, are likely the causes of the decrease in height of black seed plants with longer weed competition periods. The outcomes concur with those [12], who found that the height of black seed plants decreased as the competition period lengthened.

3.4 Number of Branches per Plant

The number of productive branches that grew during weed crop competition at different intervals is shown in Table 2. Another crucial characteristic of this variety is the number of productive branches per plant, which varies greatly depending on the amount of water, nutrients, and stress-inducing environmental elements. The weed-free plot had a much higher total number of productive branches (6.30) than the weedy check plot, which had the lowest number (3.66). As the competition lasted less time, there were more fruitful branches overall. The 15-day period produced the most productive branches (6.29), while the 45-day and 60-day periods produced 4.93 and 5.77 branches, respectively. Additionally, compared to branches evaluated 75 days after emergence, the total number of productive branches recorded 30 days after emergence was considerably higher. Longer competition periods result in a greater quantity of weed biomass and density, which can be explained by the decrease in the overall number of productive branches. This increased weed presence limits the availability of vital resources such as nutrients and moisture for the crop, reducing its growth and development. [14] similarly supported our results, when compare the weed-free and no-weeding treatments. They found that each plant had 8 branches in the weed-free condition and 4.75 branches in the weeded condition.

Table 2: Impact of various periodic weed interference on plant height and number of branches per plant.

Traits / Treatment	Plant height(cm)	Number of Branch per Plant
Weed Check	42.30b	3.66b
Weed Free	58.66a	6.30a
Duration 1 (15 DAE)	58.46a	6.29a
Duration 2 (30 DAE)	58.08a	6.17a
Duration 3 (45 DAE)	48.80ab	4.93ab
Duration 4 (60 DAE)	51.13ab	5.77ab
Duration 5 (75 DAE)	48.80ab	4.86ab

***Means with the same letters are not significantly different at $p \leq 0.05$**. DAE (day after emergence).

3.5 Number of Capsule per Plant

There were notable variations in the quantity of capsules per plant between weed-free and weedy check plot (Table 3). Weedy check had the lowest value (5.26), whereas weedy free had the maximum number of capsules per plant (13.66). The increased rivalry between weeds and agricultural plants over the course of the plant's life was the reason for the minimum number of seeds per plant. Crop plants eventually had fewer branches and shorter capsules as a result of weeds depleting resources. [13,14] documented a decline in the fruit-bearing capacity of fennel plants with longer competition periods. They also noted that the number of capsules per plant increased as the duration of the weed-free period increased.

3.6 Number of seed per capsules

The periods of competition from weeds significantly influenced the quantity of black seed capsules produced by each plant (Table

3). The weed-free treatment yielded the highest number of seeds per capsule, which was statistically comparable to the 15-day competition phase after emergence. The weedy check had the fewest capsules, which was statistically equivalent to the competition period of 75 days after emergence. The differences between the competition periods 45, 60, and 75 days after emergence were statistically comparable. The lowest number of seeds per plant was caused by increasing competition between weeds and crop plants over the course of their lives. Due to the depletion of nutrient resources caused by weeds, agricultural plants developed smaller capsules and fewer branches. Additionally, fennel plants that strengthen during the competition phase have a reduced potential to yield fruit, according to [13].

3.7 1000 seed weight (g)

The weight of 1000 seeds is a key yield element in crop productivity, as it contributes directly to the total yield of the grain. In this study, no significant differences in the weight of 1000 seeds were observed between the different competition durations showed in table 3. [15] Found same observation when they examined the effects of periodic weed competition on the 1000-seed weight of rapeseeds. They discovered that there was no significant effect on the 1000-seed weight and that the sensitivity of rapeseed plant seed development to early season weed pressure was not as high as that of other yield components, such as number of capsules per plant and seed yield ha^{-1}.

3.8 Seed yield (Kg ha^{-1})

Analysis of the statistical data showed that the duration of competition between weed and the crop has a significant impact on seed yield (Table 3); as demonstrated, the Weed-Free (pure stand) produced the highest yield of 1128.4 kg ha^{-1} compared to Weedy Check and Duration 5 (75 DAE), which produced the lowest yield of 227.56 kg ha^{-1} and 421.19 kg ha^{-1}, respectively, according to statistical data analysis. The results clearly show that No-Yield to Crop increases with the amount of time weeds stay in the field.

During the initial weeks following crop emergence, weed competition is minimal. Since there were no competing weeds during this time, the crops are doing well and are growing healthily. In order to better collect nutrients from the soil and receive more sunlight for photosynthesis than a crop plant that is weed-inhabited, the crop plants would have grown taller and had more branches in the absence of weed competition. The rate of photosynthesis and the capacity to translocate assimilate to the developing seeds were both accelerated by these ideal growing conditions, which led to an increase in resource accumulation, sink strength, and seed weight. Although the weeds had little to no impact on the crops' growth, as time goes on, the crops' capacity to withstand weed pressure declines. Crop growth and productivity are significantly reduced as a result of the crops' diminished capacity to withstand the competition. The weed index, which shows yield losses due to weed competition, shows this tendency. The two periods with the biggest yield losses were Duration 5 (62.68%) and the weed check (79.85%). Just 9.7% was the lowest yield loss recorded in Durations 1 and 2, which were 15 DAE and 30 DAE, respectively.

The maximum seed yield is guaranteed and any potential financial losses from competing weed/crop growth are reduced when the black cumin plant is grown without weeds for the first forty-five days. This study confirms earlier research by [11, 16] and shows that timely weed treatment results in higher grain yields because weed-crop competition takes less time. These findings indicate that the important time of weed competition begins at Duration 3 (45 DAE), highlighting the necessity of early and efficient weed management techniques to preserve the potential for blackseed output. the duration of blackseed interference by weeds. the bare minimum of time without weeds needed to prevent a yield loss of more than 10%. According to Figure 3 and Table 3, the key weed infestation period started at 45 DAE.

Table 3: Impact of various periodic weed interference on yield and yield components.

Traits / Treatment	No. of Capsule per Plant	No. of seed per capsule	1000-seed weight (g)	Seed yield (kg ha^{-1})
Weed Check	4.91c	67e	6.37 a	227.56bc
Weed Free	16.87a	119.625a	7.04a	1128.4a
Duration 1 (15 DAE)	14.30ab	118.25a	7.02a	1018.6a
Duration 2 (30 DAE)	14.30ab	114.58ab	7.01a	1018.4a
Duration 3 (45 DAE)	10.17abc	109.07bc	6.90a	741.4ab
Duration 4 (60 DAE)	12.73ab	106.06	6.93a	856 ab
Duration 5 (75 DAE)	8.72bc	84.86d	6.44a	421.19bc

***Means with the same letters are not significantly different at p≤ 0.05.** DAE (day after emergence).

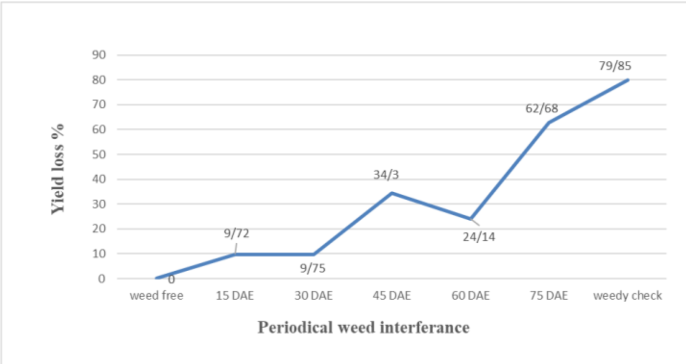

Figure 3: Periodic weed interference's impact on yield losses. DAE (day after emergence).

3.9 Biological yield (kg ha^{-1})

The biological yield under various weed competition durations is shown in Table 4. The weedy check plot (3000 kg ha^{-1}) and duration 5 (3111 kg ha^{-1}) approaches were both outperformed by the zero-weed plot (no weeding), which produced the maximum biological yield (7556 kg ha^{-1}). As the length of weed competition decreased, a significant improvement in biological yield was noted. The maximum yield (6889 kg ha^{-1}) was obtained by limiting weed competition to 15 days following crop emergence. This yield was significantly greater than the yields at 45 and 60 days (6000 and 6622 kg ha^{-1}) of weed interference, respectively. Biological yield decreased as a result of longer weed interference and shorter weed-free periods. This is in line with the findings [15] who found that rapeseed produced a minimum of 907 kg ha^{-1} when weeds were continuously present and a maximum of 18,778 kg ha^{-1} when weeds were absent. Additionally, [17] reported that barley reached a remarkable 19.52 tons per hectare, with the highest biological yield observed in weed-free plots.

3.10 Harvest index(%)

According to Table 4, the weed-free plots had the greatest harvest indices (16.56), while the weedy checks had the lowest (8.95). The harvest index tended to decline as the weed competition period shortened; it reached its lowest point (12.64) 30 days after emergence. This was statistically considerably lower than both measurements performed 45 and 75 days after crop emergence, including the harvest indices recorded for 45 days after emergence (11.17) and 75 days after emergence (10.95). The study's findings showed that weed competition decreased harvest indices and, in most situations, favored vegetative growth over reproductive development. [18] found that increased translocation of photosynthetic materials to crop shoots resulted in the movement of photosynthetic products away from reproductive structures (fruits, seeds).

3.11 Seed Oil Content (%)

As seen in Table 4, during the time that weeds were present, a variety of factors had an impact on the oil content of black cumin seed. After competing with weeds in the weedy treatment, the oil content of black cumin seed decreased. In terms of black cumin seed oil content, the weed-free treatments had the largest quantity at about 38.75%, while the weedy treatment had the lowest at 27.92%. According to [12], because weeds and crops vie for the same nutrients and environmental circumstances, the amount of oil produced dropped as the weeds fought for the black cumin seeds. Thus, lower photosynthetic activity was the cause of the decreased oil output. According to [2], black cumin seeds produced oil yields ranging from 32.0% to 36.33%.

3.12 Oil Yields (kg ha^{-1})

The findings demonstrated that competition from weeds at different phases of growth had a significant impact on *Nigella sativa* L. oil yield. The amount of oil obtained was 63.53 kg ha^{-1} less than that from a plot that was entirely weed-free, at 437.255 kg ha^{-1}, based on the quantity of weeds present during the entire growth season. Furthermore, as Table 4 illustrates, there was a clear correlation between oil and grain yields. Having said that, the observation that the overall decline in both grain and oil yields indicates that *Nigella sativa* has a limited competitive ability against a greater crop of weeds confirmed the association between oil yields and grain yields [12] and [19], who observed that yields of grains and oils declined when competition with weeds rose with canola.

Table 4: Impact of various periodic weed interference on biological yield, harvest index, oil content and oil yield.

Trait / Treatment	Biological yield (kg ha^{-1})	Harvest Index (%)	Oil content (%)	Oil yield (kg ha^{-1})
Weed Check	3000b	8.95b	27.92e	63.53f
Weed Free	7556a	16.56a	38.75ab	437.255a
Duration 1 (15 DAE)	6889a	12.68ab	35.32bc	395.769b
Duration 2 (30 DAE)	6889a	12.64ab	33.57bc	341.87bc
Duration 3 (45 DAE)	6000a	11.17b	30.58cd	226.72de
Duration 4 (60 DAE)	6622a	12.39ab	33.11bc	283.42cd

Duration 5 (75 DAE)	3111b	10.95b	28.67de	119.49e

***Means with the same letters are not significantly different at p≤ 0.05.** DAE (day after emergence).

Conclusion

The findings of this study show that different weed interference durations significantly affect black seed (*Nigella sativa* L.) growth and production. The findings showed that prolonged weed duration, particularly after 45 days after emergence, led to decreased plant height, fewer branching, fewer capsules/plant, poorer seed yields, and lower harvest indices. Early and effective weed removal will improve black seed crop performance and yield throughout the first 30 to 45 days of cultivation. It is predicted that the essential weed control phase for black seed begins approximately 45 days following emergence. Maintaining weed-free conditions is essential to preventing yield losses of more than 10% at this time. Optimizing black cumin yield in an organic or low-input agricultural system, where synthetic pesticides are restricted or outright forbidden, requires early weed management intervention.

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